

**ENLIGHTENING LIGHTNING!**  
**PRODUCING AND DIRECTING A MULTIMEDIA PLANETARIUM SHOW**

A Thesis

by

SARAH MARIE FOWLER

Submitted to the Office of Graduate Studies of  
Texas A&M University  
in partial fulfillment of the requirements for the degree of

MASTER OF SCIENCE

December 2004

Major Subject: Visualization Sciences

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Approved as to style and content by:

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Donald H. House  
(Chair of Committee)

---

Richard Orville  
(Member)

---

Carol LaFayette  
(Member)

---

Phillip Tabb  
(Head of Department)

December 2004

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## ABSTRACT

### Enlightening Lightning!

Producing and Directing a Multimedia Planetarium Show.

(December 2004)

Sarah Marie Fowler, B.S., The University of Texas

Chair of Advisory Committee: Dr. Donald H. House

Starting with a group of lightning researchers, planetarium staff, and visualization specialists, an academically diverse group was formed through a grant from the National Science Foundation to develop a planetarium show on lightning. The show target audience is middle school aged children. The goal of the show is to teach lightning safety and lightning facts in an immersive environment. Through the use of video, an animated character, and a meteorologist, the curriculum is presented to the audience. I fulfilled the roles of producer and director through all aspects of production. My role also included maintaining group organization and communication throughout show production.

This paper discusses my experiences in producing *Enlightening Lightning!* by starting with outlining the curriculum and finishing with putting it all together at the planetarium. The goal of this paper is to discuss the techniques and organizational methods used to manage a diverse group and produce a multimedia show.

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## INTRODUCTION

In September of 2002, The National Science Foundation awarded a grant to Texas A&M University and Tarleton State University to produce an educational planetarium show on lightning. By combining resources from both campuses, *Enlightening Lightning!* would educate middle school aged children in the 6<sup>th</sup> through 9<sup>th</sup> grades on lightning facts and safety. Richard Orville from the Atmospheric Sciences Department at Texas A&M would serve as the Principal Investigator. Donald H. House from the Visualization Sciences Laboratory at Texas A&M and Michael Hibbs, the planetarium director at Tarleton State University, would both serve as Co-Principal Investigators. Denise Martinez from Tarleton State University and Edward Mansell from the National Severe Storm Laboratory at the University of Oklahoma would serve as associated scientists. These individuals from various geographic locations would collaborate to produce a multimedia planetarium show.

Each campus has different resources to help produce the show. The Tarleton State Planetarium is a 40 foot dome with 18 slide projectors, two digital video projectors, two DVD players, one CD player, and surround sound. The planetarium also has a computer controlled digital star field projection system. The Visualization Laboratory has two dimensional and three dimensional software programs along with compositing and video production software.

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This thesis follows the style of *Journal of Educational Psychology*.

The lab also has a studio and digital video cameras and other auxiliary video equipment. There are lightning experts, planetarium staff, and visualization specialists on the team as well.

I joined the project in January of 2003 as the show producer and director. At that time, the main group had met together to discuss the available resources and possible show story lines. I first analyzed the main show resource, the planetarium. Developing a show for a planetarium is significantly different than producing a video. Many visual representations are contained within some sort of boundary, such as a frame, edge of the movie screen, or computer monitor. A planetarium is an example of an immersive space. In the purest form, immersive spaces have no boundary or surrounding frame. By completely surrounding the visitor, immersive spaces create the illusion that the visitor is no longer in the venue but inside the projected world. To create an effective show, I needed to understand the abilities and limitations of the planetarium.

This paper discusses my experiences in producing *Enlightening Lightning!* by starting with outlining the curriculum and finishing with putting it all together at the planetarium. I begin with background research on how immersive spaces are unique from more traditional media. From this research, I then provide a detailed methodology of the show production. Using informal show evaluation criteria found in research, I then discuss how *Enlightening Lightning!* addresses each issue. Finally I end with concluding remarks and suggestions for future research. The goal of this paper is to discuss the techniques and organizational methods used to manage a diverse group and produce a multimedia show.

## BACKGROUND

Interest in immersive spaces can be argued to date back to the cave paintings. As art developed, paintings covered entire rooms of homes and buildings. Often they would tell a story as one looked around the room. Other paintings however showed only one moment in time, such as those found at the Villa dei Misteri as seen in Figure 1, where the actions occurring on one wall happen at the same instant in time as those on the surrounding walls. Created in 60 B. C., the painting covers all four walls (Grau, 2003). In this way the artists sought to show the “unity of time and place” (Grau, 2003, p. 23).

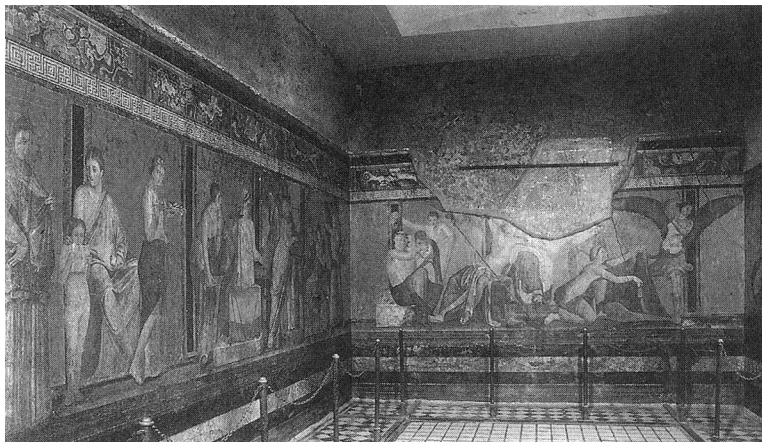


Figure 1. Villa dei Misteri. Room 5, Pompeii, 60 B. C.

Reprinted with permission from *Virtual Art: from illusion to immersion* (p. 26), by O. Grau, 2003, Cambridge, MA: MIT Press. Copyright 2003 by Soprintendenza Archeologia di Rome.



(A)



(B)

*Figure 2.* (A) Landscape room in the Villa Livia, near Prima Porta, 20 B. C.  
(B) Detail of room.

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Another example of room paintings, the Villa Livia at Prima Porta, Figure 2A and 2B, creates the “illusion of an artificial garden” (Grau, 2003, p. 29).

Though the painting lacks great depth, visitors are transported into a forest of many trees and realistic birds that completely fill their field of vision. Surrounded on all sides, visitors are immersed in the “space of illusion” (Grau, 2003, p. 29).

Along with the idea of depicting one moment in time, artists have to make a choice – to represent things as they actually are on a plane surface, orthogonally, or how they are perceived with our eyes, foreshortening through perspective (Kelso, 1992). Artists in the Renaissance period used precise perspective calculations to create even more realistic deceptions. Baldassare Peruzzi painted the walls, floor and ceiling of Sala delle Prospettive using exact perspective measurements to create columns and pillars as well as a painted window showing a “view” of Rome as shown in Figure 3 (Grau, 2003, p. 38). The primary function of this room is “to give the visitor the feeling of being in a virtual temple” (Grau, 2003, p. 39). In *Virtual Art*, Grau considers Peruzzi’s room to be “the most remarkable example of a High Renaissance space of illusion” (2003, p. 38).

From painting the walls of rooms, the focus shifted in the 16<sup>th</sup> century to the ceilings. Some of these Baroque paintings, such as in the church of Sant’Ignazio by Andrea Pozzo, merged the real architecture with painted architecture to extend the ceiling into heaven. Another example of elaborate ceiling painting is the Sistine Chapel in Rome. The chapel is “a vast immersive



*Figure 3. Sala delle Prospettive. Baldassare Peruzzi, 1516, Rome, Villa Farnesia*

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display system designed to invoke a sense of awe” (Lantz, 1997). Viewing all the works requires movement of the eyes, head, and body producing a tangible immersive experience (Lantz, 1997).

Also during the 16<sup>th</sup> century, artists including Gaudenzio Ferrari worked on recreating Jerusalem in Italy through a series of chapels, the Sacro Monte di Varallo. Pictured in figure 4, *Calvary*, one of the chapels by Ferrari, creates a three dimensional experience through the use of terracotta figures in front of painted backgrounds. This technique in which three dimensional objects appear to grow out of the picture’s surface or stand free in the area between the viewer and the painting was later called faux terrain (Grau, 2003). The addition of the faux terrain to the already “illusionistic fresco” creates an “immersive presence”



Chapel no. 13



Chapel no. 38

Figure 4. Calvary at Sacro Monte, Varalla by Gaudenzio Ferrari.

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that draws the viewer into the scene (Grau, 2003, p. 44).

In striving to create the most realistic and illusionary art possible, artists also turned to the available technology of the time, the camera obscura. Making its first appearance in the 16<sup>th</sup> century, the camera obscura lets light in through a small pinhole and produces an exact image. This technique “perfected a new fusion of art and technology” which occurred through the physics of optics and the desire for realistic imagery (Grau, 2003, p. 53).

The birth of the panorama with Robert Barker in 1787 began by patenting the process of producing an image in correct perspective on a circular canvas. The first panorama covered a 180 degree view of Edinburgh and was 21 meters long. Later panoramas were created inside of rotundas and covered areas of 930 square meters. These paintings covered a full 360 degrees and “developed into a presentation apparatus that shut out the outside world completely” (Grau, 2003, p. 59). The panorama’s greatest achievement was not its ability to create



an “immersive sphere” but rather it’s “sophisticated from of a 360 degree illusion space created with the means of traditional painting” (Grau, 2003, p. 62).

Along with the many praises of the new art form, the panorama had critics as well. Some did not accept the panorama as a true illusion of reality. “They felt that is should have everything, smell, sound, etc” (Grau, 2003, p. 64). Without all the senses accounted for, these critics felt the panorama “left one feeling confused and trapped” (Grau, 2003, p. 64). Other critics saw the panorama and were fearful of the power in the illusion. Thus we have those who view the panorama as “a danger to perception and consciousness” versus “those who welcome it as a space for projecting their fantasies and visions of fusion with all-pervasive image worlds” (Grau, 2003, p. 64). Overall the panorama was highly popular and “quickly became a favorite medium for art, education, political propaganda, and entertainment” (Grau, 2003, p. 66).

At the beginning of the 20<sup>th</sup> century, the advent of film promised to deliver the realistic experiences that the panorama no longer could fulfill. “Like the panorama before it, film began by replicating what could actually be experienced to establish its potential as a medium” (Grau, 2003, p. 151). Similar to early responses to the panorama, film audiences were initially “overwhelmed” by the new experience (Grau, 2003, p. 152). Eventually “habituation chips away at the illusion,” and audiences became “hardened to its attempts at illusion” at the same time increasing their interest in “content and artistic media competence” (Grau, 2003, p. 152). “This process, where media of illusion and the ability to distance

oneself from them compete, has been played out time and again in the history of European art since the end of the Middle Ages” (Grau, 2003, p. 152).

In 1923, the first planetarium was opened. With the “Model 1” Planetarium, Carl Zeiss created the first real use of domes and projection screens for night skies. The planetarium accurately projected the celestial skies onto a domed screen and showed the night sky to thousands of school children among other patrons (Shaw & Lantz, 1998). Even this first planetarium was used as an educational tool (Hagar, 1974, p. 43). While astronomy shows still predominate in planetariums, many different types of programs are now shown for both educational and entertainment purposes.

In the early 1950’s, scientists Norbert Wiener and Alan Turing were working on communication methods between humans and machines (Grau, 2003, p. 161). Their work formed the basis for virtual reality by using “communication between humans as the model for communication with or between machines” (Grau, 2003, p. 161). Various scientists continue to develop communication methods, such as graphical user interfaces, head mounted displays, and interactive gloves (Grau, 2003).

With the potential for creating more immersive spaces, artists began to work with the new technology, and scientists began to think of themselves as artists (Grau, 2003, p. 166). Beginning in the 1980’s immersive installations became a new form of art. Groups such as the Banff Center for the Arts in Canada, the SIMLAB at Carnegie Mellon University, MIRALab at the University of Geneva, and the Centre for Advanced Inquiry in the Interactive Arts developed

to aid and encourage artists in developing interactive immersive art. Today artists continue to “search for illusion using the technologically most advanced medium at hand” (Grau, 2003, p. 350).

Designers of large-scale immersive theaters also desire a completely immersive experience for the audience. Ed Lantz, a leader in the development of advanced visualization systems, continually seeks ways to “deliver an eye-limited resolution image with a wide instantaneous field-of-view such that the entire retina is excited to its full capacity” (Lantz & Thompson, 2003). Some video based examples include the CAVE at the University of Illinois at Chicago, head-mounted displays, and various wrap around video projection systems. Recent developments include full video based digital domes. Often considered the planetariums of the future, these domes can accommodate large audiences and are used to educate as well as entertain. In 2003, fifty five digital domes existed throughout the world with many more in planning and construction stages (Lantz & Thompson, 2003).

The public is very interested in educational science programs. From the biennial survey by the National Science Foundation, 90% of adults are interested in new scientific discoveries and yet only 15% feel at least moderately informed about science and technology (National Science Board, 2002). Educational institutions, such as planetariums and museums, can help increase scientific awareness through informal or “free-choice” learning experiences. Free choice learning happens throughout one’s lifetime and is essential to making well-informed life choices (Falk & Dierking, 2000).

People attend free choice learning events for a variety of reasons. Adults go to satisfy their “curiosity” and to enjoy “fun and intellectually stimulating environments” (Falk, Donovan, & Woods, 2001). They often bring their children so they can have an enjoyable as well as a “worthwhile and educational” time (Falk et al., 2001). Children like to come to see and do new things (Falk et al., 2001). Ultimately, “people participate in free choice learning to satisfy a personal sense of identity, to create a sense of value within the world, and to fulfill personal intellectual and emotional needs; what has come to be referred to as ‘meaning making’” (Falk et al., 2001, p. 3”).

Along with education and learning, visitors to free choice venues also seek an enjoyable experience. People want their experiences to be “pleasurable and entertaining” (Buckingham & Scanlon, 2002, p. 9). This mix of education and entertainment is referred to as edutainment. Often edutainment “relies heavily on visual material, on narrative or game-like formats, and on more informal, less didactic styles of address” (Buckingham & Scanlon, 2002, p. 8). Edutainment provides a way to reach “audiences that have limited access to accurate information or are reluctant to process this information” as well as to encourage participation among “less motivated students” (Ritterfeld, Weber, Fernandes, & Vorderer, 2004, p. 4).

Continuous science learning is of particular importance in the creation of free choice programs. People with basic science knowledge “may have an easier time following news reports and participating in public discourse on various issues pertaining to science and technology” (National Science Board,

2002). Science education is “not easily confined to school hours and years,” so knowledge must be available outside of the classroom (Falk et al., 2001, p. 4). Giant screen filmmakers recognize this “huge need to increase science literacy in the general public” (Silleck, 2000, p.78). With each film created, filmmakers are given the “unique opportunity to enlarge perceptions and enrich lives” (Silleck, 2000, p. 81). By nature, science is “ever-changing” and thus “requires a lifelong commitment in order to remain literate and current” (Falk et al., 2001, p. 4). The public pieces together their science knowledge from a wide variety of sources, including “non-academic books, television (public, commercial, and cable), newspapers and magazines, on the job experiences, museums, and to a more limited degree, radio and the Internet” (Falk et al., 2001, p. 11). All of these must be taken into consideration when assessing overall science learning in the population.

A well researched example of free choice learning and edutainment is educational television shows. In the 1960’s the highly successful entertaining and educational television show for children, *Sesame Street*, was launched by the Children’s Television Workshop (Revelle, 2003, p. 1). The show is produced through “expertise in media production, educational content (or curriculum), and research with children” (Revelle, 2003, p. 2). Researchers work with children and producers in the developmental stages of show production, and an independent research company evaluates the effectiveness of the final show (Fisch & Truglio, 2001). *Sesame Street* has gone on to be “the most researched television show in history” (Fisch & Truglio, 2001).

Other programming at the time usually “represented the vision and agenda, as well as the script and studio direction, of a single individual” (Fisch & Truglio, 2001, p. 6). While other educational series such as *Captian Kangaroo* were in production in the 1960’s, these shows featured “lessons invented by scriptwriters who possessed no training in education or child development, made no use of expert consultants or advisors, and answered to no education stake holders” (Fisch & Truglio, 2001, p. 7). In contrast, the *Sesame Street* team relied on the “collaboration of researchers and producers” (Fisch & Truglio, 2001, p.21). The educators take the lead role in outlining the content of the show while producers explore the best presentation format. Researchers take these ideas and work with children to help refine them. Later on researchers work with children to determine the effectiveness of the shows (Revelle, 2003,p. 3). This integration of research and production was once described by Joan Ganz Cooney of the Children’s Television Workshop as “a marriage worth keeping intact – for the sake of the children” (Fisch & Truglio, 2001, p. 21). By creating a diverse team of researchers and producers, “the resulting television series thus becomes something stronger than any one of these groups could have created on its own” (Fisch & Truglio, 2001, p. 240).

Today producers create shows for venues such as planetariums, museums, IMAX theaters, and interactive virtual theaters. In these specialized theaters, the “strong feeling of presence or immersion” allows the audience to ignore the usual “distracting influences” and concentrate on the show (Ritterfeld et al., 2004, p. 6). After partaking in one enjoyable educational experience,

people are more likely to seek out similar activities and further increase their knowledge (Ritterfeld et al., 2004). Adults report that their behavior is changed for weeks after viewing these films (Flagg, 2000). Another result of immersive shows is a desire to talk about the show with others and seek more information on the topic, thus reinforcing the concepts learned (Flagg, 2000).

Planetariums themselves are a unique media. The complete darkness, large 360 degree dome, stereo sound system, and overall immersive feeling of the space create an ideal environment for capturing the audience's attention. The immersive experience inside a planetarium is so powerful that it can create feelings of physical movement, such as falling or flying, for the viewer. Domes invoke more of our senses and project images with a large field of view which increases our "feelings of expanse, naturalness, depth, and powerfulness" (Shaw & Lantz, 1998). Domes are also able to "reproduce a more natural looking image with an unlimited number of vanishing points in all directions" (Shaw & Lantz, 1998). Because the environment is so different from a traditional video or film, educational shows created for planetariums have the potential to have a much greater impact on the audience. Concluding with the words of Jon Shaw and Ed Lantz: "Since reality is immersive, are we not better served by making our entertainment and education environments immersive" (1998).

## METHODOLOGY

The goal of the project *Enlightening Lightning!* is to produce an educational and entertaining planetarium show about lightning for middle school children. Through a grant from the National Science Foundation, a team of lightning experts, planetarium staff, and visualization specialists was created. I fulfilled the roles of director and producer of the show. First the group decided on the content of the show, including the science facts and storyline. From there, a writer wrote the script. After reviewing and editing the script, the storyboards and animatic were created. Then the video was filmed and edited. Next we gathered slides, sound effects, and other media to accompany the video. Finally the whole show was put together at the planetarium. Before progressing from one step to another, the whole group would meet together to discuss and finalize the previous work so the next stage could begin. As the director and producer, I oversaw all the transitions from one step to another as well as maintained the communication between members.

The grant from the National Science Foundation established the core group members. Richard Orville from the Atmospheric Sciences Department at Texas A&M is the Principal Investigator and served as one of the group's lightning experts. Donald H. House from the Visualization Laboratory at Texas A&M is a Co-Principal Investigator and oversaw the visual effects and organization of the project. Michael Hibbs, the planetarium director at Tarleton State University is also a Co-Principal Investigator and oversaw assembling the show at the planetarium. Also from Tarleton State University are Denise



Martinez and Larry Barr. Martinez worked on programming vector graphic effects, and Barr, the assistant planetarium director, worked on putting all the show pieces and sound effects together. Edward Mansell, a lightning research scientist from the National Severe Storms Laboratory in Oklahoma, served as another lightning expert and consultant. Graduate students from the Visualization Laboratory included Luke Carnevale, Jeff Alcantara, and myself. Carnevale focused primarily on our animated character while Alcantara worked on designing vector graphic effects along with other animations. These individuals are the core Enlightening Lightning! team.

My first goal was to develop a story line and decide on the content of the show. The story line ties the whole show together and provides continuity for the science curriculum. Middle school aged children are the target audience and therefore my main focus at this time and throughout the show development. The science facts presented needed to be age appropriate to ensure understanding and comprehension. If the curriculum was presented in a manner that is too challenging, the show would seem boring, and the audience would lose interest. To prevent this, I used the book *Understanding Lightning* by Martin Uman to develop the show curriculum. *Understanding Lightning* takes a list of general lightning questions asked by “non-scientists” and provides answers in easy to understand, “non-technical terms” (Uman, 1971). This is how I wanted to impart information as well. As a group we then selected the lightning concepts from Uman’s book we found to be the most interesting and relevant. We also considered lightning safety to be a highly important topic along with the

development of storms and lightning. Following is the list of the questions we chose from *Understanding Lightning*.

1. Why did Benjamin Franklin fly the kite?
2. How does a lightning rod work?
3. How many people are killed by lightning each year?
4. What should I do if caught outdoors in a thunderstorm?
5. Is it safe to talk on the telephone during a thunderstorm?
6. Should I unplug radios and TVs?
7. How can I help someone struck by lightning?
8. Am I safe from lightning in an airplane? In a car?
9. How does lightning damage trees and buildings?
10. Does lightning “never strike twice”?
11. Does it always strike the tallest object?
12. How are thunderstorms formed?
13. Are there locations with no lightning?
14. How many thunderstorms are in progress in the world at one time?
15. Does cloud lightning differ from cloud-to-ground lightning? Which is more common?
16. Does lightning occur only in thunderstorms?
17. Does a stroke between cloud and ground travel upwards or downwards?
18. How long and how wide is the lightning channel?
19. Why is lightning zig-zag?

20. How hot is lightning?
21. How is thunder generated?
22. How can it be used to measure the distance and length of the lightning channel?
23. Does lightning occur without thunder? Thunder without lightning?
24. What is heat lightning? Sheet lightning?
25. Has lightning any practical use?

In addition to the questions from *Understanding Lightning*, the scientists in our group, Richard Orville and Edward Mansell, added a few more scientific topics to the curriculum as well. Their additions were:

1. Space lightning, sprites,
2. Triggered Lightning,
3. Lightning monitoring and warning systems,
4. Cloud development and formation,
5. Storms in cold fronts,
6. Lightning occurring during the Apollo 12 launch,
7. Research centers such as the University of Florida and New Mexico,
8. Computer models and simulations of lightning,
9. NASA satellite data,
10. Balloon borne experiments,
11. Elementary electrostatics.

The answers and explanations to both lists provided the basis for our curriculum.

The questions seemed to naturally fall into three categories: those which require very detailed and scientific explanations, those which are fun and interesting facts, and those which concern lightning safety and pseudo science. We divided the questions into those three categories. These categories served as the main organizational structure of the show. Many planetarium shows rely solely on narration to present ideas and instruction. I wanted this show to be more interactive and entertaining for audiences. To maintain audience interest and present each idea appropriately, each category was assigned a different presentation method. Detailed science questions are presented by a meteorologist, fun facts are handled by an animated character, and safety and pseudo science are addressed by a family going on a hike. The family provides the main storyline for the show with the meteorologist and animated character appearing throughout the show to further explain science concepts the family encounters throughout their day. Through the dialogue of the family, all the science concepts are linked together. Narration is not the focus of the show. Instead, the focus is on the interaction of the family members and the events of their day. The storyline for the family provides the skeleton of the show. Each segment of their day provides a new setting and opportunity to introduce new science facts. The family events also formed the beginning of the show outline.

Before creating the outline for the show, I first worked on the character development for the family members as well as the meteorologist and animated character. Keeping the target audience in mind, the family consists of a mom, dad, and two children. The children are the same age as our target group and

enjoy learning about science and lightning. The older child is a girl named Jenn. She's 15 years old. Jenn is fairly knowledgeable about science and lightning. She is always interested in learning more though. Her younger brother, Davie, is 12 years old. Davie is also interested in science, but he doesn't know as much as his sister. Davie and Jenn's father on the other hand knows very little about science and lightning. He's filled with pseudo-science such as "lightning never strikes the same place twice." Mom helps balance out dad with her practical knowledge. She knows how to keep her family safe and encourages them to learn more. She learns a lot of her science knowledge from television. She especially enjoys the weather channel. This family has many different views to offer on lightning. Davie and Jenn provide some school book answers. Dad provides a way to clear up pseudo science while mom enforces safety.

The role of the meteorologist is played by Rebecca Miller, a meteorologist of NBC5 studios in Ft. Worth, Texas. She is a friend of the planetarium director, Michael Hibbs, and was excited to work on the project. As the meteorologist in the show, Miller answers the technical science questions. She has a very personable and friendly nature that the audiences enjoy watching. NBC5 Studios generously supplied all of Miller's video and audio recordings for the project.

Our animated character, initially nicknamed Sparky, is an electron. While creating the show outline, a consensus on who Sparky is was not reached. Later on the writer worked on creating a character description for Sparky, and the scientists refined the character for greater scientific accuracy. Ultimately Sparky, is an electron trying to find his perfect "molecule family." Sparky is a quirky guy

who likes talking to the kids in the audience. He has a funny high pitched voice with traces of a Texas accent. In between the family video segments, Sparky comes by to tell the audience more about the science that is happening in the story. He has props and slides to illustrate his discussions. Sparky also provides some comic relief. Luke Carnevale sketched, modeled, rigged, textured, and animated Sparky (Carnevale, 2004). Ruben DeLuna provided the voice talent.

In the planetarium show, I decided to have the family going on a hike, a somewhat more modern activity instead of a picnic, the initial idea. The audience will visit the family at various points throughout the family's day. First the audience will see the family in the kitchen getting ready for their day. Then the family is seen hiking through the forest. Later the family stops to eat lunch as a storm develops. Next the audience sees the family in a lightning shelter at the park. Finally the family returns home and reviews what they learned through out the day.

Taking the storyline of the family as a rough outline, the curriculum questions are spread throughout the day. A few additional safety concepts were added in to the outline in addition to the other curriculum. The final show outline appears in Figure 5.

Once the outline was completed, I decided to find an experienced writer to create the script. I created a flyer which I posted around campus at Texas A&M. The flyer was also posted on campus at Tarleton State University. On the internet, I posted the flyer on various writer group sites and email lists. The flyer provided a brief description of the project and asked for a writing sample. I

received about 4 different samples. From those I selected my choice and then presented the options to the group. Our chosen writer is an engineering graduate from Texas A&M, Victor Van Scoit. His writing sample produced vivid characters with distinct personalities. He worked on the characterization of Sparky and developed interesting and funny dialogue for him as well as the family.

After I selected Van Scoit as our writer, the cyclical process of writing and revising began. Van Scoit would write a few pages, and I would make revisions and suggestions. After a significant portion of the script was ready, I sent it out to the entire group for additional suggestions and revisions. Once the entire script was written, the whole group met in College Station for a collective review. At that meeting we went through every line of the 22 page script until the group as a whole was satisfied with the dialogue. Stage directions and notations for effects were added into the script at this time as well. Barr finalized the script by reformatting it using the screenwriter's industry standard.

Night sky then video of sunrise  
 Sunrise is opening for weather show with Rebecca Miller  
 Camera pulls back to kitchen with weather show on TV

Morning Weather and News  
 Chance of rain in the forecast

Breakfast, family watching weather and planning hike  
 Lightning mentioned in forecast  
 Why did Benjamin Franklin fly the kite?  
 Elementary Electrostatics

Hiking in the park, see lightning damaged tree  
 How does lightning damage trees and buildings?  
 Does lightning “never stroke twice”?  
 Does it always strike the tallest object?

Lunch at the lake, clouds forming  
 Sparky talks about cloud formation  
 Cloud development simulation  
 How are thunderstorms formed?  
 Cloud models  
 Storms in cold fronts

Swimming – family is watching swimmers  
 Water safety – thunder distance rule  
 30-30 rule  
 Interaction of ice crystals with water, separation of charge  
 How hot is lightning?  
 How is thunder generated?  
 How can it be used to measure the distance and length of the lightning channel?  
 Does lightning occur without thunder? Thunder without lightning?  
 What is heat lightning? Sheet lightning?  
 Does cloud lightning differ from cloud-to-ground lightning? Which is more common?  
 Does lightning occur only in thunderstorms?  
 Balloon borne experiments  
 Triggered Lightning  
 Apollo 12  
 Research centers

Seeking Shelter  
 How does a lightning rod work?  
 How many people are killed by lightning each year?  
 What should I do if caught outdoors in a thunderstorm?  
 Is it safe to talk on the telephone during a thunderstorm?  
 Should I unplug radios and TVs?  
 How can I help someone struck by lightning?  
 Am I safe from lightning in an airplane? In a car?  
 Lightning monitoring and warning systems

Active Storm  
 Does a stroke between cloud and ground travel upwards or downwards?  
 How long and how wide is the lightning channel?  
 Why is lightning zig-zag?  
 Lightning in space, sprites

Dinner, back at home  
 The family reviews what they’ve learned that day.  
 Has lightning any practical use?  
 Forest Ecology  
 Are there locations with no lightning?  
 How many thunderstorms are in progress in the world at one time?  
 NASA satellite data

Credits

*Figure 5. Final Show Outline.*



Since the script was now in a working form, I needed to find actors.

Donald House, one of the co-principal investigators on the project, has contacts within the local theater group. From there I was able to fill the roles of Mom, Dad, Jenn, and Davie. The actors chosen are shown in Figure 6. Two fairly minor roles of lifeguard and person one were still unfilled at this point.

To introduce the actors to the production team as well as to each other, I arranged a meeting with both groups. At that time I also had the actors read through the script out loud with each other. I filled in as the lifeguard and person one during this first rehearsal. This meeting was recorded on tape for later review and to facilitate creation of the storyboards and animatic. The actors were pleased with the script and looked forward to the filming. Several more rehearsals followed in the next two months (see Figure 7).



*Figure 6. Actors. J. Paul Teel (Dad), Tina Evans (Mom), Sara Roman (Jenn), Michael Green (Davie).*

Photos provided by actors.

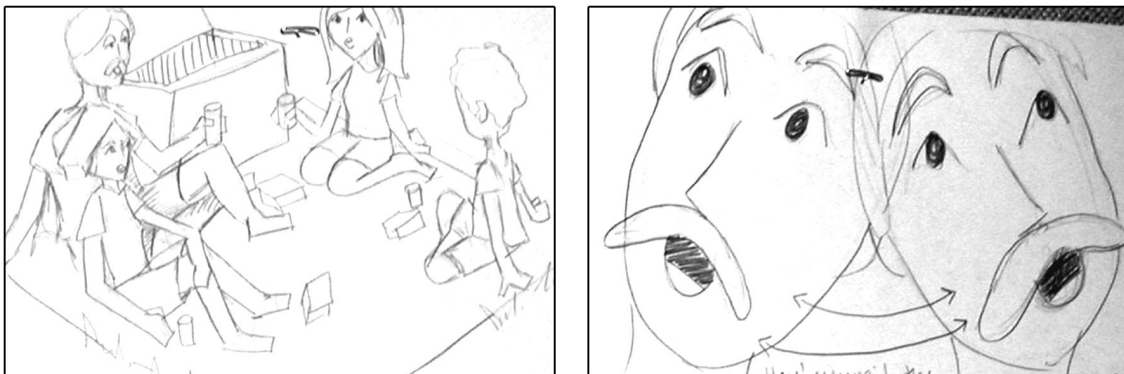
As the actors worked on memorizing their lines, Luke Carnevale and I worked on creating the storyboards. Using the script as a guide, we divided up

the dialogue into scenes and camera angles. Then we sketched out the shot for each scene and pinned the sketches chronologically on the wall. A sample of the storyboard artwork is show in Figure 8. We also cut up the script and pinned the dialogue underneath the corresponding sketch. This served as the first visual representation of the video portion of the show. All the sketches were then scanned into the computer. I then created a website with the storyboards and corresponding dialogue and sent it out to the rest of the group.



*Figure 7. Rehearsals in the studio.*

Photos by Richard Orville.



*Figure 8. Storyboards. Family at lunch (left). Dad looking for sun (right). Sketches by Sarah Fowler.*

I started the website the first month I began working on the project. Some of the first information posted included group contact information and the show curriculum. As the project progressed, I continued to add new information to the site. The team was geographically located across two states and three different cities. Maintaining communication and presenting progress to the other team members was one of my primary functions. As the body of information grew, I changed the design of the website to best organize the data. I sent an email to all the team members anytime I made a change to the site or posted new show material. As much as possible, I tried to maintain and update our working website with the current progress so the distant team members were always aware of the status of the show.

As another way of visualizing the final show, Carnevale and I created an animatic, a real time version of the show that synchronizes the storyboard images to recorded audio. For the actors' dialogue, I digitized the audio recordings taken during the script reading. I used temporary voice recordings for meteorologist Rebecca Miller and Sparky. Using a non linear video editor, DPS Velocity, I pieced in the scanned storyboard images to go along with the dialogue recordings. I then created VHS copies and sent them to the rest of the group. The animatic was the first real time representation of the show.

The story of the family takes place in two locations, the kitchen and the park. While we continued to rehearse with the actors, I was also scouting out locations. Initially I was interested in Bastrop State Park, which is about an hour and a half away. I then visited Lake Somerville State Park, only thirty to forty five

minutes away. At the park I looked for a good hiking trail (one that was wide enough to fit all the video equipment), a place for lunch near the lake, and a lightning shelter. Lake Somerville offered all these things and was willing to accommodate our group. Photos taken during this trip are shown in Figure 9. The other location is the kitchen. While scouting out kitchens, I was looking for space for the video equipment as well as the ability to manipulate morning and night appearances. A place with less windows was more ideal for our situation. Davie, our boy actor, had a friend whose kitchen had all these attributes. Figure 10 shows the two different kitchens.

To decrease the time commitment of our actors, I decided to do the video shooting in two days, one day at the park, and another in the kitchen. I also invited Glen Vigus, the video production specialist of the Visualization Laboratory at Texas A&M, to be our video director. Vigus has experience working with a large crew and managing the flow of a video shoot. He came to our last rehearsal in the studio to meet the actors and become familiar with the team. By this point the role of lifeguard was filled by a current Texas A&M student with some previous acting experience. I also arranged for the production crew and Vigus to visit Lake Somerville without the actors before the video shoot. Then when it was time to film, everyone would be ready and prepared. Figure 11 shows photos of our scouting trip.





*Figure 9.* Lake Somerville State Park. Shelter (left). Hiking trail (right).  
Photos by Sarah Fowler.



*Figure 10.* Kitchen options. Chosen Kitchen (left). Too many windows in second kitchen (right).

Photos by Sarah Fowler.



*Figure 11.* Scouting at Lake Somerville.  
Photos by Richard Orville.



Filming all the shots went fairly smoothly. With Vigus in charge, everyone knew their job and helped holding bounce cards or following along with the script. I checked off every shot to ensure everything would be on film. A week later we followed the same procedure with the kitchen scenes. All the video work was done in two days. Photos from our video shoot appear in Figure 12.



*Figure 12. Video Shoot at Lake Somerville.*  
Photos by Richard Orville (top left, bottom left, bottom right) and Sarah Fowler (top right).

After the filming, I returned to the lab to begin editing the clips. First I selected only the takes I needed from the tapes and only digitized what was necessary to conserve computer space. Then following the script, I pieced together the clips. Many of the shots required color correcting. In a planetarium

environment, large white areas often produce washed out images across the dome. The bright white bounces around the dome to a much greater degree than in traditional film. In our kitchen scenes, white kitchen cabinets often framed the family members. I toned down the white cabinets by adjusting the luminosity values. Using the waveform monitor, I checked each scene to ensure that the color values stayed within U.S. Broadcast requirements, adjusting the luminosity as necessary.

In addition to ensuring that the white cabinets did not overpower the planetarium, the shelter scenes, which were shot on a bright sunny day, needed to be darker and stormier. The faces of the family members were already the correct exposure but the background was very bright and sunny. Fortunately the actors were sitting during the shelter scene and not moving around the frame. Using Adobe Photoshop I created black and white mattes around the actors. I then blurred the matte to soften the transitional boundary. Then using Adobe AfterEffects, I used the matte to make color adjustments only to the background. To create the stormy appearance, I decreased the amount of yellow and green in the scene as well as decreased the overall luminosity. The result was a stormier environment that did not suggest a warm sunny day outside the shelter.

The video is only one portion of the show however. The Tarleton State University Planetarium has 18 slide projectors, two DVD players, two video projectors, one CD player, an 8-track digital tape unit, and surround sound; all housed inside a 40 foot dome. Six slide projectors are used to create *All Skies*, one image that fills the entire dome. Six other projectors create panoramas that

cover the 360 degree horizon line. Three sets of two projectors project onto the front of the dome and are used to create slide dissolves, where one image fades into the previous one. In the center of the dome is a *DigiStar* system. The *DigiStar* is programmed to project vector graphic animations on the entire dome. Two overlapping video projectors project onto the front of the planetarium as well. One projects onto a smaller portion of the dome, and the other covers a larger area. Speakers surround the outside of the dome to create a surround sound experience. A diagram of the planetarium appears in Figures 13 and 14.

For our production, the video of the family on the small video projector only covers a small percentage of the dome. Sparky is shown on the large video projector. Slides and other effects are needed to fill the space and create an immersive experience. I scheduled a meeting at the planetarium to show the edited video footage on the dome and to decide on the surrounding slides and effects. This was perhaps the most important meeting we had during the production of the show.

At the meeting, we watched the show on the dome and developed a sense of what else we needed. As a group, we then went through the entire script and made a list of what slides and effects we would like to have. At that point we needed 49 different categories of slides consisting of both illustrations and photos, eight different video clips, four *DigiStar* animated effects, one panorama, and four *All-Skies*. I divided these up among the team according to who was best suited to find these materials.



Back at Texas A&M, I then began work on the illustrations. With Ruben DeLuna, the voice of Sparky as well as an accomplished graphic artist, I began researching and then sketching out the illustrations. I then passed the sketches on to Seth Freeman, another graphic artist, who then created the final images in Adobe Illustrator. Figure 15 shows an example of a sketch and the resulting slide. Along with working on the slides, I was contacting photographers and collecting more of the non-science related slides.

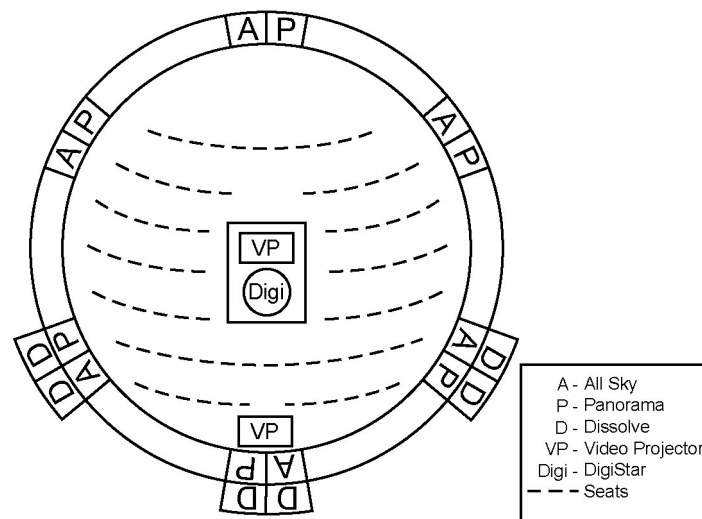


Figure 13. Diagram of Tarleton State Planetarium.

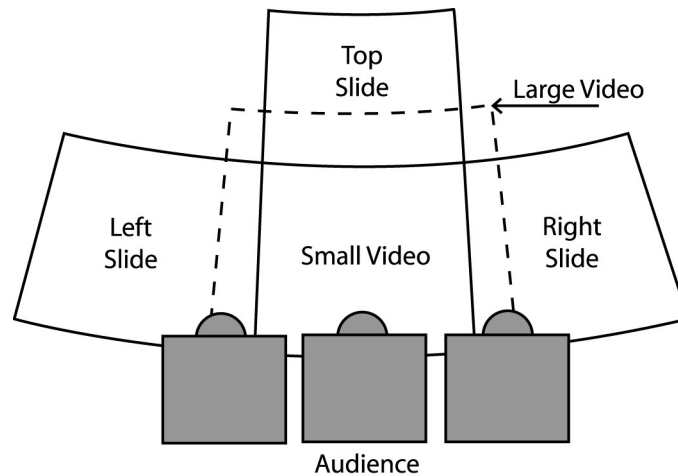


Figure 14. Tarleton State Planetarium, audience perspective.

Jeff Alcantara joined the group at this point to work on the additional animations and DigiStar effects. Some of these included flying a kite in the rain, swirling cloud particles, a close up look at an atom, and a slow motion lightning flash. Effects that were created specifically for the *DigiStar* were also rendered as video for potential use in planetariums without a *DigiStar* system.

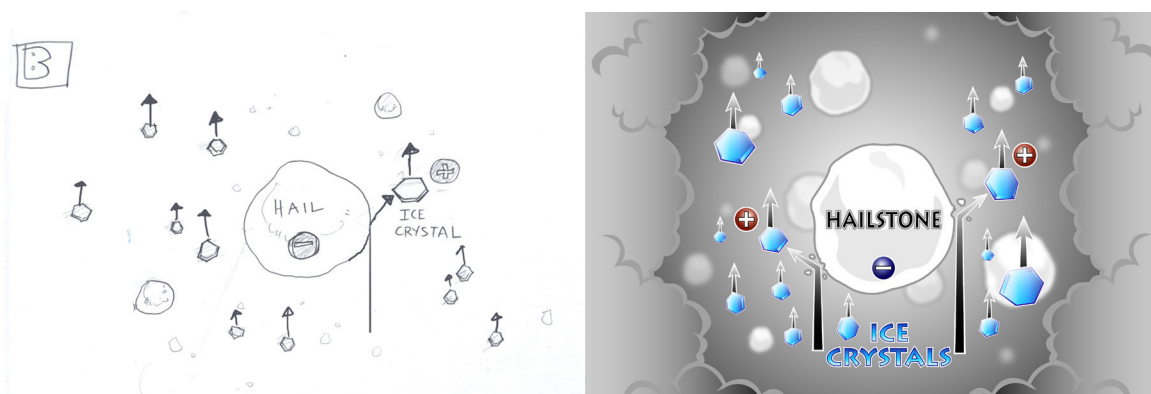


Figure 15. Sketch (left). Resulting slide (right).  
Sketch by Ruben DeLuna. Slide by Seth Freeman.

Carnevale continued to work on the Sparky animation. Sparky was timed with the dialogue to point to things happening elsewhere in the planetarium, such as slides appearing. He then gives the appearance that he is “controlling” the slide projectors. Sparky also talks directly to the audience members. He helps the audience feel at home in the planetarium, and that they are an integral part of the show.

Also at this time, I began looking for a musician to write a score for the show. The limitations on our budget encouraged me to use locally available resources. As a group we had two musician contacts, one through Rebecca Miller at NBC5 news and one through Michael Hibbs at the planetarium. Both musicians submitted resumes and samples to me. We were fortunate that Ron Dilulio, the friend of Michael Hibbs, has created many scores for planetariums and television shows. His samples showed a great diversity, and he has a wealth of experience to draw upon. I chose him to produce the score, and he was pleased and excited to work with our group.

As the due date for the show approached, I realized that we would not have all the video and slide materials that I had originally requested. At that point I began looking for much of the materials myself. I contacted NASA for video footage as well as searched government websites for photographs. I was able to find a few more items, but not everything. After a few modifications to the list, a few more resources came in, and all the show pieces were complete.

I then sent all the materials to Larry Barr at the planetarium. He added in sound effects and put all the show pieces together. Using special planetarium

software, Barr synced the slides to the video and created the immersive show we were all working towards.

My main job as director was ensuring that the final product was scientifically accurate, entertaining, and thought provoking. Hopefully the audience will learn more about lightning and leave feeling better informed and interested in science.

## RESULTS AND EVALUATION

I will evaluate *Enlightening Lightning!* using informal criteria suggested by individuals involved in the creation of giant screen films. Christopher Palmer, President and CEO of the National Wildlife Productions, INC of the National Wildlife Federation has outlined many goals for immersive shows (1998; 2000). Hyman Field, the National Science Foundation Informal Science Education Program Officer, also has an evaluative list for educational programs (1995).

Large format shows should be entertaining and create interest in the planetarium experience. The show should also increase awareness in the subject matter as well as teach new concepts and ideas. The show should give the audience members a new experience to remember. While maintaining scientific accuracy, the show should help develop an appreciation for scientists and the scientific method. These guidelines can be applied to the evaluation of *Enlightening Lightning!*

To encourage people to attend educational shows, the “film must be entertaining and compelling” (Palmer, 1998). Field says that you should always ask “does the film ‘get their attention?’” (1995). *Enlightening Lightning!* meets these criteria in several ways. Quick, fun dialogue is exchanged between the family members. Dad is often a source of entertainment as he always says the wrong answers. The actor playing Dad, J. Paul Teel, does a fantastic job bringing the character to life and making the show enjoyable to watch. The animated character, Sparky, is another source of entertainment. Sparky’s quirks and fast movements help to maintain audience interest. Sparky always has a

new prop to use and then throw away behind his back. Together, the family dialogue and Sparky work to create and maintain an entertaining environment.

Another important aspect in an educational show is the quality of information and increasing the knowledge of the audience. Palmer believes the film “must convey useful information” and “add to the knowledge base” (1998). This planetarium show was written and produced with two lightning scientists. These scientists were responsible for the detailed curriculum as well as overseeing the implementation of the curriculum into the final product. Before the dialogue was written, the curriculum was in place. The lightning facts and information presented were selected for relevance to our target audience, middle school aged children. The show was checked many times for inaccuracies or misperceptions. Even the character of Sparky, originally an electron seeking his proton, was changed to reflect correct science standards. Sparky is now an electron seeking his “molecule family.” Additional information relates to lightning safety. This is repeated at the end of the show to reinforce these concepts. Audiences will leave with more knowledge about cloud formation and lightning and a much better idea of how to protect themselves and others during a thunderstorm.

Palmer states that “the film must provide viewers an opportunity to observe nature and science they may not have otherwise” been able to observe (Palmer, 1998). In a unique medium such as a planetarium, show creators are able to “provide viewers with opportunities to see real things that they cannot easily experience in their everyday lives” as well as things they will never see

(Palmer, 2000). *Enlightening Lightning!* takes audiences to places they will never experience, such as the inside of a cloud. The DigiStar is used to simulate the ice crystals falling downwards and super-cooled rain drops flying upwards. In another part of the show, an actual lightning storm is created in the planetarium. Through strobe lights and thunder sound effects, the audience is placed in the middle of a lightning storm. This unique experience gives the audience a new look at a thunderstorm.

Giant screen shows should also create an appreciation for science and scientists in the audience members and show scientists at work. From the National Science Foundation's 2002 report regarding public attitudes and understanding of science and technology, "scientists and engineers are almost always portrayed (in the entertainment industry) as unattractive, reclusive, socially inept white men or foreigners working in dull, unglamorous careers" (National Science Board). This is significant because "image has a lot to do with how effective the communication is in capturing the attention of the public. The more appealing the image, the more likely that people will listen to what is being said" (National Science Board, 2002). In providing this unrealistic "nerdy" view of scientists, children "could reject science and engineering as potential careers" (National Science Board, 2002). Field hopes the audience leaves an educational film with "a little bit of knowledge of specific facts," but, more importantly, a greater appreciation of science along with the "process" and "relevance of it" (Field, 1995). In *Enlightening Lightning!* our on camera scientist, meteorologist Rebecca Miller, is charismatic and personable. She makes science easy and fun

to learn. Towards the end of the show, Miller talks about other scientists and where they work. Photographs of scientists and their work environments are shown alongside the video. These slides include men, women, and graduate students. They are shown working in the laboratory, in the office, and out in the field. From this, the audience can see that everyday people are scientists, and anyone can study to become one.

The show “must dispel pseudo science, misrepresentations and myth” (Palmer, 1998). Through Dad, many lightning related myths are introduced. Dad thinks that lightning never strikes the same place twice as well as believes it’s best to stand under a tree during a lightning storm. The rest of the family, Sparky, and Miller all work to correct these ideas and teach Dad the correct answers.

Palmer also feels it is important to reach different learning styles and age groups with an educational film (1998; 2000). *Enlightening Lightning!* has a family with two children in our target audience age group. Younger age groups, while finding the film enjoyable and educational, will probably not grasp all of the science concepts. Older audiences will also enjoy the film, but may find some of the material quite basic. To fulfill the grant requirements, the show is directed at the middle school aged audience.

Two different learning styles are met in the show. The dialogue provided by the family, Sparky, and Miller helps educate auditory learners. Video, DigiStar effects, and slide diagrams provide strong visuals for visual learners. We did not have a professional teacher on our team. Specific learning styles were not



researched or directly addressed during the creation of the show. Different languages are not currently available either.

Above is an evaluation of the show using informal guidelines. Below is an evaluation of the team organization.

As the producer and director of *Enlightening Lightning!*, I was responsible for overseeing the whole show production as well as maintaining group communication. Through Yahoo! groups, we set up a group email address that sent messages to every member of the team. By emailing [lightningshow@yahoo.com](mailto:lightningshow@yahoo.com), the message was sent to every team member who joined the group. All the main group members were signed up as well as other faculty and staff who were interested in the progress of the project. Having one email address that reached everyone worked out well for our group.

Another means of group communication was our website, <http://www-viz.tamu.edu/students/sarah/lightning>. I designed and maintained this site throughout show production. Curriculum notes, storyboards, script revisions, scouting photos, and schedules were just some of the items posted there. Slides as well as current show progress were also available. Individual contact information for all group members was also posted at a password protected page. Whenever changes were made to the website, an email was sent to the group with a link to the changes. As far as posting information and ensuring it was available to all group members, the website worked well for me. Often the other group members would just follow the link to the changed information and

then not visit the site again until a new email was sent. For group communication purposes, email worked better than just visiting a website.

During the entire project, I also set up weekly conference calls on the telephone. These calls were to check in with everyone and address any questions. This was also a good time to ensure that everyone was making progress on their part of the show. We used phone conferences to set up physical group meetings as well. Working with everyone's schedule proved challenging at some points. Meetings at either Texas A&M or Tarleton University had to be scheduled weeks in advance and were often subject to postponement. I always sent an email following conference calls if any important information was discussed, such as setting up future meetings. Conference calls were good to check in with other group members and hear everyone's voice. However, the follow up email provided written confirmation of any discussion or future plans.

Individuals' phone numbers were posted as part of the password protected web page. On several occasions a direct call from Texas A&M to Tarleton University was made to clear up any confusion. During the end of show production, more of these calls were made as I was gathering all the final show pieces. Direct phone calls gave more concrete answers but left other group members out. I tried to use conference calls whenever possible to include everyone.

The few times that we did meet together at one location, it was imperative that all group members be there. On a few occasions, we were missing one or two people. Since it was extremely difficult to plan these meetings, if attempts to

reschedule failed, I conducted the meeting without the missing members.

However major decisions for future show direction were often reserved for these group meetings. Even with missing members, these decisions were still made by those that were present. Later on, this created communication problems with the absent members that continued through out the rest of production. While the best decisions were made given the circumstances, the project would have flowed better had all group members been present at all major meetings.

## CONCLUSION

Coordinating a diverse team of lightning scientists, planetarium staff, and visualization experts, I directed and produced a planetarium show on lightning. *Enlightening Lightning!* is a 40 minute show directed at middle school aged children. The curriculum, script, visual slides, effects, and soundtrack were all created for the target audience. After viewing the show, the audience leaves with a greater understanding of lightning and lightning safety and the unique, immersive planetarium experience.

Many things went well throughout show production. From the beginning, the lightning scientists were involved in show development. They helped write the curriculum and edit the script. A scientist was also present at all major meetings and helped outline additional effects and slides. Their involvement throughout the whole process was crucial to the output of a factually correct and entertaining show.

Outlining the curriculum goals before the creation of the script or show outline was also beneficial. This allowed for a natural progression from the curriculum to the show outline and then the script. The lightning facts then created the backbone for the rest of the show. Also, by creating detailed character descriptions, the writer produced an excellent script from the beginning with very believable characters.

Physically meeting together as a group enabled good group communication. Between all of the major steps, I called group meetings. All group members would travel to either Tarleton University in Stephenville, Texas

or Texas A&M University in College Station, Texas to approve the current status of the project and agree upon the next step. Ensuring that everyone was informed and ready for the next step was very important in the show production. This also ensured that no fundamental changes could be made in the future that would dramatically alter past work.

Involving an experienced meteorologist and television personality was another good idea. The narration of the show was provided by Rebecca Miller, a meteorologist from NBC5 in Ft. Worth, Texas. Miller did an excellent job working on her portion of the script as well as providing a professional performance. Using a certified meteorologist added credibility to her narration, and her previous experience on television provided us with a natural and practiced performance.

Most of our actors came from the local theater group and had prior work experience. I also allowed ample time for the actors to become familiar with the script and attend rehearsals. When it came time for filming, everyone was prepared, and video shooting time was minimized. However, a few of our actors joined our group during the week before filming. They did not have sufficient time to rehearse or work with the other actors. During filming, we wasted time and tape with multiple takes. It was very apparent which actors had sufficient time to prepare and felt comfortable before the camera.

By scouting out the video shoot locations ahead of time, I was also able to ensure a smooth video shoot. All of the main crew became familiar with the set and potential camera positions. There were very few questions on the day of

shooting about how to set up. Introducing Glen Vigus to the group as our video director was also an excellent idea. Vigus had experience working with actors and directing a set. He played an integral role in creating a solid working environment for the cast and crew.

Assigning two graduate students to focus on the animated effects was a good plan. Our animated character, Sparky, was the creation of Luke Carnevale. He did all the work on Sparky including the sketches, modeling, rigging, shading, lightning, and animating. By having one group member focus on Sparky, the continuity of the character was maintained throughout the entire show. Carnevale produced an animated character that is sure to be remembered by audiences. Another group member, Jeff Alcantara, was assigned to work on additional animations as well as DigiStar effects. By having two separate animators with separate tasks, the work flow was easily managed, and the results were excellent.

For communication between group members, the website worked well to record and store all of our project data and information. The current status of the project as well as contact information for all group members was always readily available. The website helped overcome the geographic distance that separated the components of the team. The group email address was also an easy and efficient way to contact the entire group. Only one email address was required to reach all members.

Another good communication tool was conference calls. Once a week, for about 30 minutes, group members from their locations participated in a

conference call. Updates about the project as well as any concerns were addressed. During this time future meetings were also scheduled and organized. Anytime a member was not able to attend the conference call, the effectiveness of the meeting was diminished.

Although there were many aspects of the show that worked well, some things could have been done more efficiently. During the development of the curriculum, the addition of an educator who specialized in middle school aged students would have been invaluable. The curriculum could have been even more tailored toward the target audience. Different learning styles could also have been accounted for and addressed at this time. The addition of an educator to the team would have provided insights into the education of middle school aged children that the current team was unable to provide.

Achieving complete group attendance at major meetings was also a challenge. Most of the group members attended all the major group meetings, however all members were not always present. When group members were absent, the actually meeting continued as planned, and major decisions were made regarding the future of the show. Problems arose when those decisions were questioned later on by absent group members. Some of these problems persisted until the end of the show production. These problems could have been minimized or perhaps eliminated if all group members had attended all group meetings.

Another mistake was discontinuing the conference calls. After the Visualization Laboratory was finished with the majority of the video and effects,

we stopped having conference calls. The planetarium was now working to put the show together. Initially it seemed that continued conference calls were unnecessary; however it was very difficult to assess show progress without the weekly calls. Email was not sufficient to verify the project status and answer any questions. Continuing the conference calls until the entire show was completed would have made finalizing the show smoother.

Partly as a result of the discontinued conference calls, we did not have multiple “beta” versions of the show. Originally I was hoping to have a group viewing of the completed show at the planetarium before public release. Without the conference calls, there was a sense that everyone was done with the project except for the planetarium staff. In reality it would have been best for all group members to meet at the planetarium to view the final show and make suggestions before the show was released.

In the future, a few changes and suggestions will make show production more efficient. For an educational show, involving a teacher as a consulting group member would produce a better tailored show for the audience. Also, involving the group members more in a group website would encourage members to visit frequently. Adding a message board or forum would make the experience more interactive instead of just passively viewing information.

By directing and producing *Enlightening Lightning!*, I brought together three diverse groups and created an entertaining and educational show. Through the use of various media, I created a planetarium show on lightning. The slides, sound effects, visual effects, and video all work together to create an



immersive learning environment. Audiences leave the show encouraged to further pursue learning about lightning and science as well as eager to seek out more immersive learning experiences.

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**VITA**

Sarah Marie Fowler  
11585 East Spanish Ridge Place  
Tucson, AZ 85730

**EDUCATION**

M.S. Visualization Sciences, Texas A&M University  
College Station, TX  
December 2004

B.S. Mathematics, The University of Texas  
Austin, TX  
May 2001